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Learning with serious games: Is fun playing the game a predictor of learning success?

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Abstract

Serious games are generally considered to induce positive effects in the areas of learning motivation and learning gains. Yet few studies have examined how these factors are related. Therefore, an empirical study was conducted to test the relationship between anticipated enjoyment and willingness to play, as well as between game enjoyment, self-reported cognitive and motivational learning gains and test results. In an explorative study, 74 children from five primary schools played the learning game AWWWARE. The results of pre- and post-tests were analysed using multiple linear regressions. The analysis showed that anticipated enjoyment played only a minor part in students' willingness to learn with serious games. Of greater importance was the students' expectation that the learning game would be easy and instructive. The level of actual enjoyment of the game also had a smaller influence than expected. While there was a correlation between enjoyment and the motivation to continue being engaged with the subject matter of the game, no effect was found with respect to self-assessed or tested learning gains. The results lead to the conclusion that other factors, such as explicit learning tasks, instruction and support inherent in the game or supplemented by teachers, may be more decisive than the experience of fun during the game.

Introduction

Educational science ascribes a range of possible benefits to the use of digital learning games (known as 'serious games'). Serious gaming is regarded as a particularly active, problem-solving, situated and social form of learning with rapid and differentiated feedback that also promotes the enjoyment of learning (Garris, Ahlers & Driskell, 2002; Kirriemuir & McFarlane, 2004; Petko, 2008; Tobias, Fletcher, Dai & Wind, 2011). A number of studies have shown positive effects from learning games in the areas of motivation to learn and learning gains (Connolly, Boyle, MacArthur, Hainey & Boyle, 2012; Ke, 2009; Lee & Peng, 2006; Vogel *et al*, 2006). Findings from general educational research strongly suggest that motivation and positive emotions are powerful factors in learning (Anderman & Dawson, 2011), and naturally, this is also supposed to be especially true for learning with serious games (Gee, 2003; Graesser, Chipman, Leeming, Biedenbach & Graesser, 2009; Malone, 1981; Prensky, 2002). However, there are also a number of reasons that such connections between fun and learning should not be considered to be self-evident.

- According to classical game theories such as those of Huizinga (1955) and Caillois (1961), enjoyment is primarily attributable to a game's freedom from utility, whereas learning games must be regarded as goal-directed activities rather than being just for fun and enjoyment.

Practitioner Notes

What is already known about this topic

- Children typically have fun playing computer games, and they feel skilled in engaging with learning games.
- Serious games may lead to greater learning motivation and thus to more effective learning when compared with traditional teaching methods.
- To achieve an optimal learning effect, the fun of the game needs to be closely linked to the learning process. Playing and learning should be integrally connected rather than merely alternating during the game.

What this paper adds

- Whether children wish to play a learning game depends less on their anticipated enjoyment of the game and more on their expectation that the game will be easy to comprehend and help them learn. Thus, primary school children already demonstrate a surprisingly clear orientation towards the learning benefits of serious games.
- Children's enjoyment of a learning game has an impact on their gains in motivation to continue engaging with the subject matter being taught. Enjoyment had no discernible effect, however, on self-reported or tested learning gains.
- Thus, to achieve greater learning gains from playing serious games, the teacher should activate children's prior knowledge and ensure that the software includes good scaffolding functions.

Implications for practice and/or policy

- Primary schoolchildren's motivation to play learning games is not primarily related to their anticipated enjoyment of the game. Rather, it can also be motivating to learn something more efficiently and better with the help of learning games.
- Enjoying the learning game does not automatically mean learning success. Indeed, learning games can encourage children's motivation to learn about a subject, but engagement with content is essential for achieving cognitive learning gains.

The findings suggest directions for further research needed in the area of game-based learning.

- Okan (2003) asked pointedly: "Are students motivated to learn, or just to play with the computer?" According to Gredler (2004), the critical issue is whether instructional designers can succeed in persuasively linking enjoyment of the game to the learning process. Resnick (2004) criticised learning games for rarely achieving this, and their inventors for tending to regard learning as 'bitter medicine that needs sugar-coating'.
- The determinants for cognitive activation and distraction can be analysed using cognitive load theory (Paas, Renkl & Sweller, 2003). According to this theory, the critical factor is to keep the distracting ('extraneous') cognitive load to a minimum while increasing the learning-related ('germane') cognitive load (Schrader & Bastiaens, 2012). Fun-related aspects of games can often be considered, as rather distracting than learning related, depending on the game and its mechanics (eg, Rieber & Noah, 2008).
- According to studies by Salomon (1983, 1984), there is reason to be concerned that learners' attention levels fall as they engage with the supposedly 'light medium' of the computer game. Whether a learning game is rather seen as a fun-related, a learning-related or a combined

activity depends on the learner and their expectations (referred to as either 'perceived demand characteristics', Salomon, 1984; or, more generally, as 'goal orientations', Pintrich, 2000). Attempts to stimulate cognitive engagement through didactic input and activities give rise to the question whether this might counteract the experienced enjoyment and whether learning gains can still be attributed to the game (O'Neil, Wainess & Baker, 2005).

- How learners perceive and interact with serious games might also be based on more general beliefs. Technology acceptance models suggest that prior expectations—including the expectation that the interaction with technology will be not only useful and easy to use, but also fun—are major predictors for willingness to work with new technologies (Venkatesh, Morris, Davis & Davis, 2003). However, it is not clear whether prior willingness to learn with video games and the expectation of fun have a measurable impact on increasing learning motivation or learning gains.

While it is traditionally a common notion that games make learning 'fun', it is less clear what 'fun' in serious games actually means and how it is related to cognitive, emotional and behavioural engagement (Deater-Deckard, Chang & Evans, 2013; Filsecker & Kerres, in press). While in learning research, 'fun' is often seen as a mediating variable in the learning process that is closely related to the learning content, general media studies take a different approach. Here, fun or enjoyment are rather seen as aspects in their own right that are dependent on aspects such as not only technological capacity, game design, aesthetic presentation, entertainment game play experience, narrativity but also challenge and competition (Malone, 1981; Shen, Wang & Ritterfeld, 2009; Vorderer, Klimmt & Ritterfeld, 2004). In conclusion, the relationship between fun and learning with serious games has yet to be fully clarified by empirical research.

Research questions and hypotheses

Based on the findings sketched earlier, the following research questions will be examined:

What kind of interrelations exist between general attitudes towards serious games, especially the expectation that this kind of learning will be fun, the actual perception of the fun of a specific serious game, perceived learning motivation and learning gains as well as improvements in post-test measures? Is expected enjoyment a predictor of actual enjoyment when learning with serious games? And is experienced enjoyment a predictor of learning motivation and learning gains?

To address these questions, the following hypotheses are tested.

H1: The more fun children ascribe to learning games, the more willing they will be to make use of learning games.

H2: The more fun children have playing a learning game, the greater will be the gains in self-assessed motivation to learn, ie, their willingness to engage with the subject matter of the learning game will increase in proportion to their experience of enjoyment.

H3: The more fun children have playing a learning game, the greater will be their cognitive learning gain by self-assessment, ie, according to their own estimation, they will have gained more knowledge and better skills related to the subject content of the learning game.

H4: The more fun children have playing a learning game, the greater will be their actual cognitive learning gain as determined by testing. They will show greater knowledge and improved skills related to the subject content of the learning game.

H1 is backed by numerous findings on technology acceptance models which suggest that prior expectations predict willingness to learn with new technology. While the main aspects for technology acceptance are considered to be perceived usefulness and ease of use, a minor factor has also shown to be anticipated enjoyment (Venkatesh *et al*, 2003). This aspect might be of particular importance in serious games acceptance (Giannakos, Chorianopoulos, Jaccheri & Chrisochoides, 2012). H2 is derived from the notion that fun of game play and motivation to

learn are not necessarily the same thing and that this can be measured independently (Fu, Su & Yu, 2009; Sweetser & Wyeth, 2005). H3 and H4 are at least partially supported by studies that show that emotional engagement, especially in a state of flow, can lead to better learning gains (Landhäußer & Keller, 2012). Whether fun and learning are actually interrelated has been a long standing topic of debate (Okan, 2003).

Methods

A Swiss research project on game-based learning to promote media competency in children and adolescents examines the use of 'serious games' in instruction and its effect on both cognitive and motivational learning gains.

Sample

In order to test the hypotheses of the study, an explorative field study was conducted in which randomly selected children worked with a computer-based learning game and were surveyed and tested both prior to and after the game about their attitudes, experiences and learning gains. The study sample consisted of 74 children from five primary school classes in Central Switzerland. The participating classes were selected based on the criterion that they had not explicitly covered information literacy in lessons so far but were willing to do so with this game-based-learning approach. In a second step, two-thirds of the students were randomly selected to participate in the study in order to achieve a minimum randomisation. The children ranged from 10 to 13 years of age ($M = 11.25$, $SD = .65$); 41 girls and 33 boys. At this age, many children start to use the Internet on a regular basis and questions of online risks and information literacy become relevant while, at the same time, gaming frequency for entertainment purposes is at its peak (Livingstone, Haddon, Görzig & Ólafsson, 2011). In effect, children in this sample were intended to be familiar with gaming but less familiar with information literacy.

Procedure

One week before the treatment, all of the children completed a prior online questionnaire (t0) to determine the children's attitudes towards learning games. A series of questions that were oriented to the six aspects of the technology acceptance model as developed by Venkatesh *et al* (2003) were asked. Each aspect was surveyed by means of several items with 5-point Likert scales, grouped with exploratory factor analysis (ie, principal component analysis with varimax rotation) and checked for reliability with Cronbach's α coefficients. The questions covered constructs related to benefits (three items, Cronbach's $\alpha = .83$), ease of use (three items, Cronbach's $\alpha = .80$), enjoyment (three items, Cronbach's $\alpha = .91$), social desirability (two items, Cronbach's $\alpha = .56$), the child's own skills (three items, Cronbach's $\alpha = .78$) and fears related to use (three items, Cronbach's $\alpha = .82$) as well as intention to use serious games in the future (three items, Cronbach's $\alpha = .86$). Responses were converted into index values using Anderson–Rubin factor scores. The advantage of Anderson–Rubin factor scores in contrast to simple sum or mean scores is that items are weighted in the final index score according to their factor loadings. Also, Anderson–Rubin factor scores employ a similar metric as *z*-standardised values (DiStefano, Zhu & Mîndrilã, 2009). As control variables, the children were asked for general information such as age and sex, language skills and school grades.

The treatment was conducted during three lessons in the classroom. Every child was given a notebook computer. First, they were asked to fill in an online test for critical information literacy (36 items, Cronbach's $\alpha = .75$) in their notebook (t1). The test items asked them to evaluate nine internet pages, each according to four evaluation criteria (credibility, fit to a given topic, completeness, neutrality). Next, the 74 children played a learning game especially developed for this study called 'AWWWARE' for 30 minutes (www.awwware.ch; Müller, Petko & Götz, 2011). This learning game is a web-based media educational 'serious game' whose goal is to promote media

Figure 1: Screenshot of AWWWARE game play

competency, particularly children's and adolescent's critical abilities when using the Internet. The game consists of an interlinked labyrinth of screenshots from web pages that serve as a playing field for the gaming tasks. The goal of the game is to locate web pages that answer specific questions, eg, "what are the main reasons for traffic accidents?". Students need to navigate the information structure provided by the game to seek suitable information while avoiding inappropriate content such as blurred pictures of violent car crashes. Players control the game by moving a small raven that holds a kite as a mouse cursor (Figure 1). Wind effects make navigating this kite a challenge and slow down the browsing behaviour. Players receive points for avoiding inappropriate web pages and selecting correct ones and get immediate feedback in the form of metaphoric weather changes. After finishing the game, players get a detailed record of their browsing behaviour along with their high score that can serve as grounds for a detailed discussion in class (Figure 2). The game was developed as an instructional tool for teachers to use in their classrooms. It is potentially of limited use when played outside an educational context that provides hints and reflection.

The study was concluded with an online post-questionnaire (t2). To assess knowledge in the domain of critical internet literacy, the children had to fill in the same online test as they did in the immediate pre-test (t1) (36 items, Cronbach's $\alpha = .76$). The number of correct answers for the pre-test and the post-test were compiled into a summary score index. In addition, further questionnaire items were used to determine self-assessed motivational learning gains (three items, $\alpha = .74$) and self-assessed cognitive learning gains (three items, Cronbach's $\alpha = .86$). Once again, index variables based on Anderson–Rubin factor scores were calculated. To evaluate the learning game AWWWARE, based on the eGameFlow Questionnaire Battery (Fu *et al*, 2009), questionnaire t2 included an appropriate scale containing eight elements: clarity of the game's purpose (Cronbach's $\alpha = .76$), interaction with the controls (Cronbach's $\alpha = .59$), strategy (Cronbach's $\alpha = .59$), use of prior knowledge (Cronbach's $\alpha = .82$), flow (Cronbach's $\alpha = .74$), feedback (Cronbach's $\alpha = .60$), available support (Cronbach's $\alpha = .72$) and enjoyment of the game (Cronbach's $\alpha = .87$). Each element is being assessed by three questions. Once again, Anderson–Rubin factor scores served as the basis for further calculations.

After assuring that statistical requirements had been met, multivariate linear regressions with simultaneous inclusion of all independent variables were performed in order to evaluate the

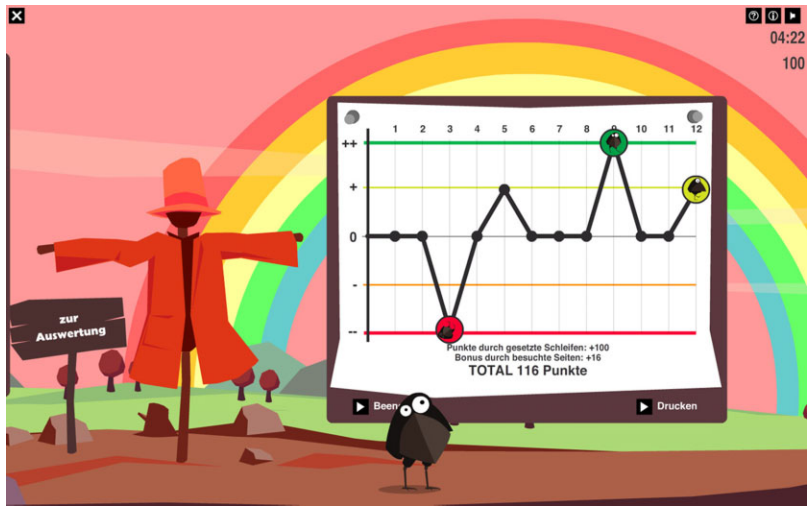

Figure 2: Screenshot of AWWWARE results screen

hypotheses. The testing sought to ascertain whether, along with other relevant variables, enjoyment of the game could be shown to have a sufficiently large and significant effect on the different dependent variables. The dependent variables, in keeping with the hypotheses cited earlier, were intention to use, and the motivational, cognitive and tested learning gains.

Results

Attitude towards learning games

Results of the questionnaires at t0 show that the students had a generally positive attitude towards games for learning. Mean scores greater than 3.00 can be interpreted as positive, scores about 3.00 as neutral and lower than 3.00 as negative. On average, the children anticipated that they would have fun (M = 3.72, SD = 1.11) and that they would be able to deal with learning games well (M = 3.80, SD = .90). On average, they also assumed that working with learning games was easy (M = 3.66, SD = .89). Table 1 summarises the children's attitudes towards learning games prior to the gaming experience.

Influence of attitude towards learning games on intention to use

The regression model to explain the intention to use as a dependent variable shows that expectations related to usefulness as well as anticipated simplicity of use have a significant influence on whether a child would like to work with serious games in the near future. This model explains 56% of the variance in the dependent variable ($F(6,67) = 14.13$; $p < .001$), which can be considered as a very large effect (Cohen, 1992; Ellis, 2010). The more positive a child's attitude towards learning games in these two dimensions, the more the child wants to use learning games. However, other dimensions, such as anticipated enjoyment, have no influence on the intention to use (see Table 2).

Evaluation of the AWWWARE learning game

After the playing sequence, the children generally evaluated the AWWWARE learning game positively. The goals of the game were clear to the children (M = 3.83, SD = .88), they were asked to use their prior knowledge in order to be successful in the game (M = 3.73, SD = .90), and they enjoyed playing AWWWARE (M = 3.96, SD = .93). Table 3 provides an overview of the individual assessment variables.

Table 1: Attitudes towards learning games

Index variable	*Item*	*M*	*SD*	*n*
Usefulness (three items, $\alpha = .83$)	'I can learn better with learning games.'	3.24	1.16	67
	'I can learn facts faster with learning games.'	3.17	1.10	69
	'When learning with learning games, I will probably get better marks.'	3.34	1.02	68
Simplicity (three items, $\alpha = .80$)	'Using learning games would be easy for me.'	3.57	1.06	65
	'I would be good at using learning games.'	3.57	1.07	63
	'It would be easy for me to learn how to play learning games.'	3.76	1.06	67
Fun/Enjoyment (three items, $\alpha = .91$)	'Learning with learning games is fun.'	3.90	1.16	67
	'Learning games make learning more interesting.'	3.69	1.12	68
	'I like using learning games.'	3.68	1.24	69
Social desirability (two items, $\alpha = .56$)	'My friends would like if I got involved with learning games.'	2.61	1.29	46
	'My parents and my family would like if I got involved with learning games.'	3.46	1.22	59
Personal ability (three items, $\alpha = .78$)	'I would be able to learn with a learning game even if nobody was there to help me.'	3.97	1.04	68
	'If I had enough time to find out how it works, I would be able to learn with a learning game even without help or instructions.'	3.71	1.15	69
	'I know enough about learning games to learn them on my own.'	3.71	1.06	69
Fear of use (three items, $\alpha = .82$)	'I'm afraid I might break something on the computer while playing.'	2.23	1.24	66
	'I'm afraid I might delete something on the computer because I click the wrong button when playing.'	2.21	1.23	67
	'I don't like learning with learning games because I'm afraid of making mistakes which I cannot correct.'	2.24	1.17	67
Intention to use (three items, $\alpha = .86$)	'I expect to learn something in the next month with learning games.'	3.09	1.27	58
	'I think I will learn something in the next six months with learning games.'	3.32	1.33	62
	'I want to use more often learning games.'	3.48	1.18	66

Note: 5-step Likert scale: 1 = *strongly disagree*; 5 = *strongly agree*.

Table 2: Linear regression: influence of attitude variables on intention to use (three items, $\alpha = .86$)

Factor	*B*	*SE*	β	*T*	p
Constant	.02	.08		.22	
Usefulness (three items, $\alpha = .83$)	.27	.13	.29	2.10	*
Simplicity (three items, $\alpha = .80$)	.33	.13	.33	2.47	*
Fun/Enjoyment (three items, $\alpha = .91$)	.21	.12	.23	1.77	n.s.
Social desirability (two items, $\alpha = .56$)	.12	.09	.11	1.23	n.s.
Personal ability (three items, $\alpha = .78$)	–.08	.11	–.08	–.75	n.s.
Fear of use (three items, $\alpha = .82$)	.14	.08	.15	1.66	n.s.

Note: $n = 74$; $R^2 = .56$; $F(6,67) = 14.13$, $p < .001$. All variables as Anderson–Rubin factor scores.
* = $p < .05$; n.s. = not significant.

Influence of enjoyment of the game on motivational learning gain

In order to analyse whether enjoyment of the game had an influence on gain in motivation to learn—ie, on a child's interest in studying the subjects of Internet research and the dangers of the Internet—we calculated a linear regression. As the dependent variable, we used the factor value for self-assessed gain in motivation to learn. Overall, this model explained 63% of the variance ($F(9,64) = 12.22$; $p < .001$). The enjoyment experienced while playing had a significant influence on gain in motivation to learn ($\beta = .22$). The greater the enjoyment experienced, the greater the interest to engage again with the subject of Internet research and the dangers of the Internet. The use of prior knowledge ($\beta = .50$), the experience of flow in the game ($\beta = .22$) and obtaining feedback ($\beta = .26$) are also significant influencing factors (see Table 4). What is interesting is that the intention to use learning games, as measured at t0, plays no apparent part in the children's evaluation of their actual experience with the game.

Influence of enjoyment of the game on cognitive learning gain

A regression analysis in relation to self-assessed cognitive learning gain shows that this dimension, unlike gain in motivation to learn, is not influenced by the experience of fun during the game. Overall, 68% of the variance can, indeed, be explained by the regression model ($F(9,64) = 15.33$, $p < .001$), but enjoyment of the game has no significant influence ($\beta = .17$). Factors with an especially positive influence on learning gain included the use of prior knowledge ($\beta = .40$) as well as the availability of feedback ($\beta = .26$) and assistance ($\beta = .20$) (see Table 5).

Influence of the experience of fun during the game on tested learning gain

When we used the child's test score as the dependent variable instead of the self-assessed cognitive learning gain, the experienced enjoyment of the game likewise had no influence ($\beta = -.14$). Only experience of flow influenced the tested learning gains ($\beta = -.34$). In this instance, the regression model is not significant overall, explaining only 20% of the variance ($F(9,64) = 1.80$, $p =$ n.s.). Moreover, none of the other independent variables showed a significant influence on the test score (see Table 6).

The inclusion of control variables such as age, sex, language skills and school grades did not yield in changes of the reported findings.

Discussion

This paper explored children's attitudes towards serious games, examining whether there is a correlation between children's experience of enjoyment of the game and their learning gains.

The first hypothesis emerged from the expectation that the greater children's anticipated enjoyment of learning games, the more willing they would be to use them. While the results of the study do show a tendency for children to have a positive attitude towards learning games, it was

Table 3: Evaluation of the learning game AWWWARE

Index variable	*Sample item*	*M*	*SD*	*n*
Clarity of the goal of the game (three items, $\alpha = .76$)	'I understood the task at the start of the game.'	4.10	1.09	73
	'I always had, the task of the game in my head right from the beginning whilst playing the game.'	3.55	0.90	69
	'The aim of the game was clear all the time I was playing.'	3.88	1.11	72
Dealing with controlling the game (three items, $\alpha = .59$)	'Controlling the game was very difficult.'	2.30	1.27	73
	'You had to be very skilful to control the game.'	3.52	1.14	71
	'I learned how to control the game very fast' (reverse item)	2.06	1.03	71
Strategic approach (three items, $\alpha = .59$)	'While playing, I carefully considered what I would get points for, and what not.'	3.62	1.04	69
	'While playing, I didn't care about the points, I just tried things out.' (reverse item)	3.14	1.04	72
	'At the end of the game I thought about what I got points for and what not.'	3.70	1.04	70
Use of prior knowledge (three items, $\alpha = .82$)	'To play the game, it was important that you knew a lot about the Internet.'	3.91	1.01	69
	'To get a lot of points I needed to know a lot about the Internet.'	3.59	1.07	70
	'To improve, I have to learn more about the Internet.'	3.64	1.13	72
Flow (three items, $\alpha = .74$)	'While playing, I was only thinking about the game.'	3.09	1.10	68
	'While playing, I forgot everything else around me.'	2.76	1.18	71
	'While playing, I didn't realise how the time passed.'	3.45	1.09	69
Feedback (three items, $\alpha = .60$)	'When I did something in the game, it showed me if it was right or wrong.'	3.78	0.98	67
	'In the game I soon realised when I was on the right track.'	3.66	0.91	71
	'While playing, I soon realised when I was on the wrong track.'	3.39	0.97	69
Help/Assistance (three items $\alpha = .72$)	'If I didn't know what to do at the beginning of the game, help was available.'	3.61	1.12	64
	'When I didn't know how to go on, the game provided help while I was playing.'	3.08	1.09	66
	'At the end of the game, the game helped me what to do.'	3.34	1.11	70
Enjoyment of the game (three items $\alpha = .87$)	'The game was lots of fun.'	4.09	0.99	70
	'I would like to play the game again.'	3.97	1.01	69
	'The game was amusing.'	3.96	1.01	69
Cognitive learning effect (three items $\alpha = .86$)	'In the game, I learned about what kind of information on the Internet is good.'	3.70	1.02	69
	'In the game, I learned about what kind of websites I should avoid.'	3.51	1.00	70
	'Because of the game I'm more aware of how to recognise risks in the Internet.'	3.57	1.09	69
Motivational learning effect (three items, $\alpha = .74$)	'The game increased my interest in the Internet.'	3.51	1.25	67
	'While playing the game I realised, I would like to learn more about how to differentiate between good and bad websites.'	3.72	1.07	71
	'Because of the game I will be more careful when using the Internet.'	3.67	1.03	70

Note: 5-step Likert scale: 1 = *strongly disagree*; 5 = strongly agree.

Table 4: Linear regression: influence of different evaluation variables on self-assessed motivational learning gain (three items, $\alpha = .74$)

Factor	*B*	*SE*	*β*	*T*	*p*
Constant	.00	.08		−.05	n.s.
Clarity of the goal of the game (three items, $\alpha = .76$)	−.06	.12	−.06	−.51	n.s.
Dealing with controlling the game (three items, $\alpha = .59$)	.11	.09	.11	1.35	n.s.
Strategic approach (three items, $\alpha = .59$)	−.17	.11	−.16	−1.50	n.s.
Use of prior knowledge (three items, $\alpha = .82$)	.50	.10	.50	4.87	***
Flow (three items, $\alpha = .74$)	.22	.09	.22	2.57	**
Feedback (three items, $\alpha = .60$)	.26	.11	.26	2.38	*
Help (three items, $\alpha = .72$)	.11	.09	.11	1.22	n.s.
Enjoyment of the game (three items, $\alpha = .87$)	.22	.10	.22	2.31	*
Intention to use (three items, $\alpha = .86$)	−.08	.09	−.07	−.85	n.s.

Note: $n = 74$; $R^2 = .63$; $F(9,64) = 12.22$, $p < .001$. All variables as Anderson–Rubin factor scores.
* = $p < .05$; ** = $p < .01$; *** = $p < .001$; n.s. = not significant.

Table 5: Linear regression: influence of different evaluation variables on self-assessed cognitive learning gain (3 items, $\alpha = .86$)

Factor	*B*	*SE*	*β*	*T*	*p*
Constant	.00	.07		−.04	n.s.
Clarity of the goal of the game (three items, $\alpha = .76$)	.03	.11	.03	.26	n.s.
Dealing with controlling the game (three items, $\alpha = .59$)	.14	.08	.14	1.75	n.s.
Strategic approach (three items, $\alpha = .59$)	.01	.10	.01	.07	n.s.
Use of prior knowledge (three items, $\alpha = .82$)	.40	.09	.40	4.18	***
Flow (three items, $\alpha = .74$)	.15	.08	.15	1.81	n.s.
Feedback (three items, $\alpha = .60$)	.27	.10	.26	2.58	*
Help/Assistance (three items, $\alpha = .72$)	.21	.08	.20	2.52	*
Enjoyment of the game (three items, $\alpha = .87$)	.17	.09	.17	1.86	n.s.
Intention to use (three items, $\alpha = .86$)	−.07	.08	−.07	−.85	n.s.

Note: $n = 74$; $R^2 = .68$; $F(9,64) = 15.33$, $p < .001$. All variables as Anderson–Rubin factor scores.
* = $p < .05$; *** = $p < .001$; n.s. = not significant.

not possible to confirm the hypotheses. In general, it was found that it was primarily the anticipated usefulness and the anticipated simplicity of learning games that influenced children's general intention to use them. This can be interpreted to mean that 'fun' or enjoyment is not necessarily the primary reason for using learning games. To put it differently: when children want to use learning games, they are not primarily interested in having fun but in the potential learning benefits and how easy these can be achieved. This questions other findings with regard to the general technology acceptance model (Venkatesh *et al*, 2003), claiming the importance of anticipated fun for the willingness to use a new technological tool. In this study, children seem to expect that serious games are primarily serious. Future research will have to show whether serious game designers should rather try to make serious games more fun (in order to raise children's expectations in this regard) or more serious (in order to fulfill expectations that these games are effective tools for learning).

The second hypothesis—namely, that gains in motivation to learn could be explained, among other factors, on the basis of the perception of fun playing the game—was confirmed by the data. More enjoyment of the game led to an increased level of interest in the subject matter of Internet research. This is consistent with other findings on the motivational effects of serious games

Table 6: Linear regression: influence of different evaluation variables on the test score learning gain (test score t2-t1, 36 items each, t1 $\alpha = .75$; t2 $\alpha = .76$)

Factor	*B*	*SE*	β	*T*	p
Constant	.64	.45		1.43	
Clarity of the goal of the game (three items, $\alpha = .76$)	.31	.69	.08	.44	n.s.
Dealing with controlling the game (three items, $\alpha = .59$)	.65	.51	.16	1.29	n.s.
Strategic approach (three items, $\alpha = .59$)	–.24	.66	–.06	–.37	n.s.
Use of prior knowledge (three items, $\alpha = .82$)	.68	.61	.17	1.11	n.s.
Flow (three items, $\alpha = .74$)	–1.39	.52	–.34	–2.67	*
Feedback (three items, $\alpha = .60$)	.02	.66	.00	.03	n.s.
Help/Assistance (three items, $\alpha = .72$)	–.34	.53	–.08	–.65	n.s.
Enjoyment of the game (three items, $\alpha = .87$)	–.56	.58	–.14	–.98	n.s.
Intention to use (three items, $\alpha = .86$)	–.42	.54	–.10	–.78	n.s.

Note: $n = 74$; $R^2 = .20$; $F(9,64) = 1.80$, n.s. All variables as Anderson–Rubin factor scores.
* = $p < .05$; n.s. = not significant.

(Connolly *et al*, 2012; Ke, 2009; Lee & Peng, 2006; Vogel *et al*, 2006). In conclusion, educational games seem to be well suited as an entry point for a new subject and to raise motivation during learning processes.

The third hypothesis, which anticipated a correlation between the enjoyment experienced in playing and self-assessed cognitive learning gain, along with the fourth hypothesis regarding a positive relationship between enjoyment of the game and test scores had to be discarded. It appears that whether something was learned was not attributable to the experienced enjoyment of the game. In contrast to results reported in previous literature, there did not seem to be a direct link between fun and learning (Connolly *et al*, 2012; Ke, 2009; Lee & Peng, 2006; Vogel *et al*, 2006). As outlined in the first section of this paper, this could be due to a number of possible reasons. One possible explanation is that—although the game was generally considered as fun—the engagement was limited to the game play and not to the game content (Gredler, 2004; Okan, 2003). Thus, fun elements can even distract students from engaging with the learning content by increasing extraneous cognitive load (Paas *et al*, 2003).

With these results, the study questions the role of 'fun' in serious games. While previous literature often claims that the main potential of serious games is directly linking 'fun' to learning, students in this study show more complex interrelations of these aspects. Ultimately, these results lead to the question, whether 'fun' and 'enjoyment' are adequate constructs to grasp meaningful motivational processes in serious game experiences. Some authors propose research on 'student engagement' as a more suitable and broader focus to analyse positive emotions when learning with serious games as it combines by aspects such as 'emotional engagement', 'behavioural engagement' and 'cognitive engagement' (Deater-Deckard *et al*, 2013; Pekrun & Linnenbrink-Garcia, 2012). While fun might still be a relevant category, future research should take other aspects of engagement into account as well.

In addition, there are several plausible explanations for these findings which can also be attributed to the limitations of the study. On the one hand, one might worry that the experienced enjoyment of the game was not sufficiently linked to the learning process, but instead was principally related to the mechanics or other non-content-specific elements of the game. It would be interesting to examine whether a closer interdigitation between enjoying the game and the learning process would lead to better learning results than simply adding on the learning content to a game structure. This kind of linkage represents a great challenge for game developers. In addition, an issue that deserves closer attention is the way the game is embedded in teaching. The

findings which have been presented suggest the importance of activating prior knowledge as well as providing feedback and assistance as needed. These support functions could either be built into the games themselves, or be provided in the accompanying lesson. Finally, the fact that enjoyment of the game does not by itself have any influence on learning success leads to questions regarding various potential interaction effects. The study has shown that students' willingness to learn with serious games is related to expectations of usefulness and ease of use rather than enjoyment. Although the self-reported level of fun positively predicted higher interest in the subject matter, enjoyment did not show an impact on self-reported or tested learning gains. Instead, for both self-reported motivation and self-reported learning gains, the use of prior knowledge was the main predictor. In conclusion, serious games should not only be 'fun' but wholesomely 'engaging'. This encompasses not only emotional but also behavioural and cognitive engagement. When teaching and learning with serious games, the combination of these aspects is key to success.

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